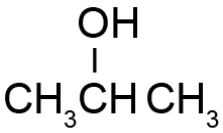
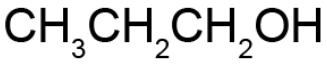
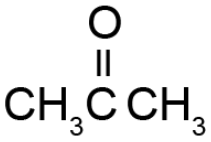
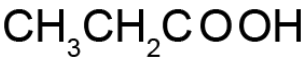
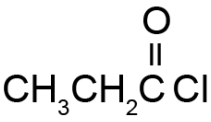
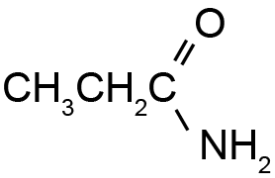
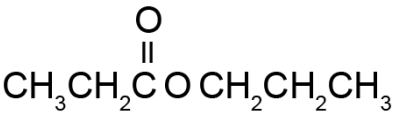
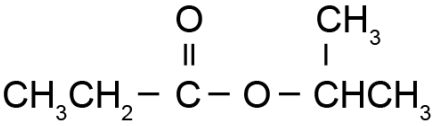
ANSWERS: **Reaction schemes**

1)

A = Propan-2-ol  **B** = Propan-1-ol  **C** = Propanone 	**D** = Propanoic acid  **E** = Propanoyl chloride  **F** = Propanamide 	**G** = Propyl propanoate  **H** = Methyl ethyl propanoate (not required) 

2)

Reagent: $NaBH_4$ / $LiAlH_4$
Type of reaction – reduction / redox

Reagent: conc H_2SO_4 / conc H_3PO_4 / Al_2O_3
Type of reaction – elimination / dehydration / condensation

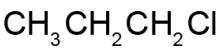
Explanation:

- An elimination reaction occurs because the molecule has changed from saturated to unsaturated / a (C=C) double bond forms.
- Because water is removed / H and OH have been removed (from adjacent C atoms).
- The but-2-ene is the major product / but-1-ene is the minor product.
- A mixture of products is formed, because the two carbons adjacent to the carbon-bearing OH have different numbers of H atoms attached / it is asymmetric.

(Zaitsev's rule – the major product has the more substituted double bond)

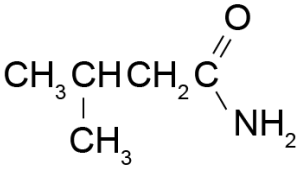
3) 1 SOCl (Accept PCl_3, PCl_5 or conc HCl / $ZnCl_2$)

B



C

4) Name: 3 methyl butanoyl chloride.
Products:

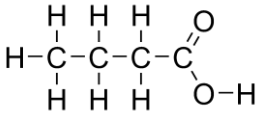


Hydrogen chloride / HCl / ammonium chloride / NH_4Cl

5) NaOH or KOH (alcoholic)
Elimination reaction
This is an elimination reaction as a hydrogen atom and a chlorine atom on adjacent carbon atoms are removed, forming a carbon-to-carbon double bond.

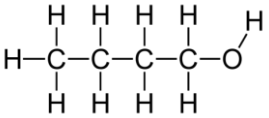
6)

a) Product A:



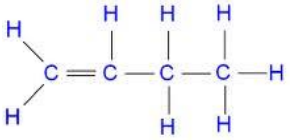
butanoic acid

Product B:



butan-1-ol

Product C:

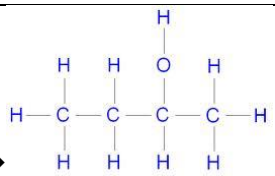


but-1-ene

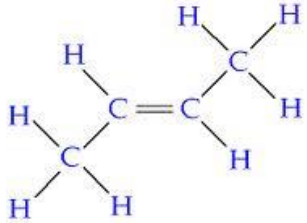
b) Reactant 1 → no reaction

Reactant 2 →butan-2-ol

Reactant 3 →

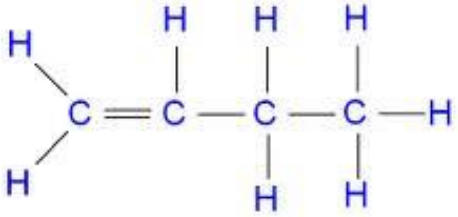


major product



but-2-ene

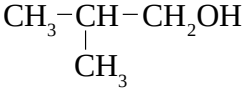
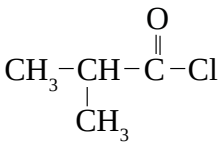
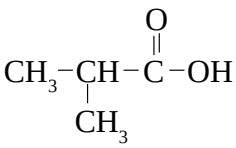
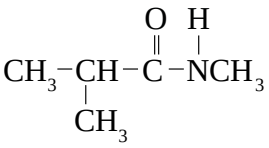
minor product



but-1-ene

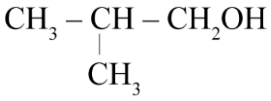
c) Butanal /aldehydes can be oxidised using $Cr_2O_7^{2-}$/ H^+ (Reactant 1) to form a carboxylic acid, butanoic acid. However, butanone/ketones cannot be oxidised.
Both butanal/aldehydes and butanone/ketones can be reduced using $NaBH_4$ (Reactant 2) to form alcohols. Aldehydes form primary alcohols and ketones form secondary alcohols.
With concentrated H_2SO_4 alcohols form alkenes.
The primary alcohol $CH_3– CH_2– CH_2 – CH_2OH$ forms only one product as the H and OH atoms on adjacent carbon atoms are replaced with a carbon-to-carbon double bond.
The secondary alcohol $CH_3– CH_2– CHOH– CH_3$ forms a mixture of products as OH is on the 2nd carbon atom. Either the 1st H is removed, forming
$CH_3– CH_2– CH= CH_2$ (minor) or the 3rd H is removed, forming $CH_3– CH= CH– CH_3$ (major).

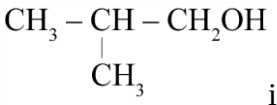
7)

W		Y	
X		Z	

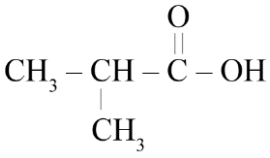
Compound W
This compound is oxidised by $Cr_2O_7^{2-}/H^+$ to an acid so it has to be a primary alcohol (or an aldehyde –

rejected as too many H atoms). The OH has to be on an end C. It's a branched chain molecule so there is a CH_3 on the 2nd C atom.
Hence:





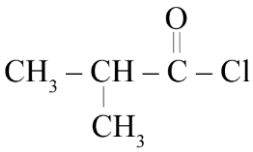
Compound X This is formed when is oxidised to an acid. Hence:



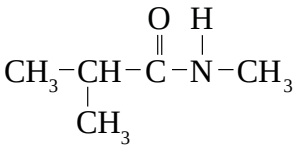
Compound Y

A substitution reaction occurs with $SOCl_2$; the OH in

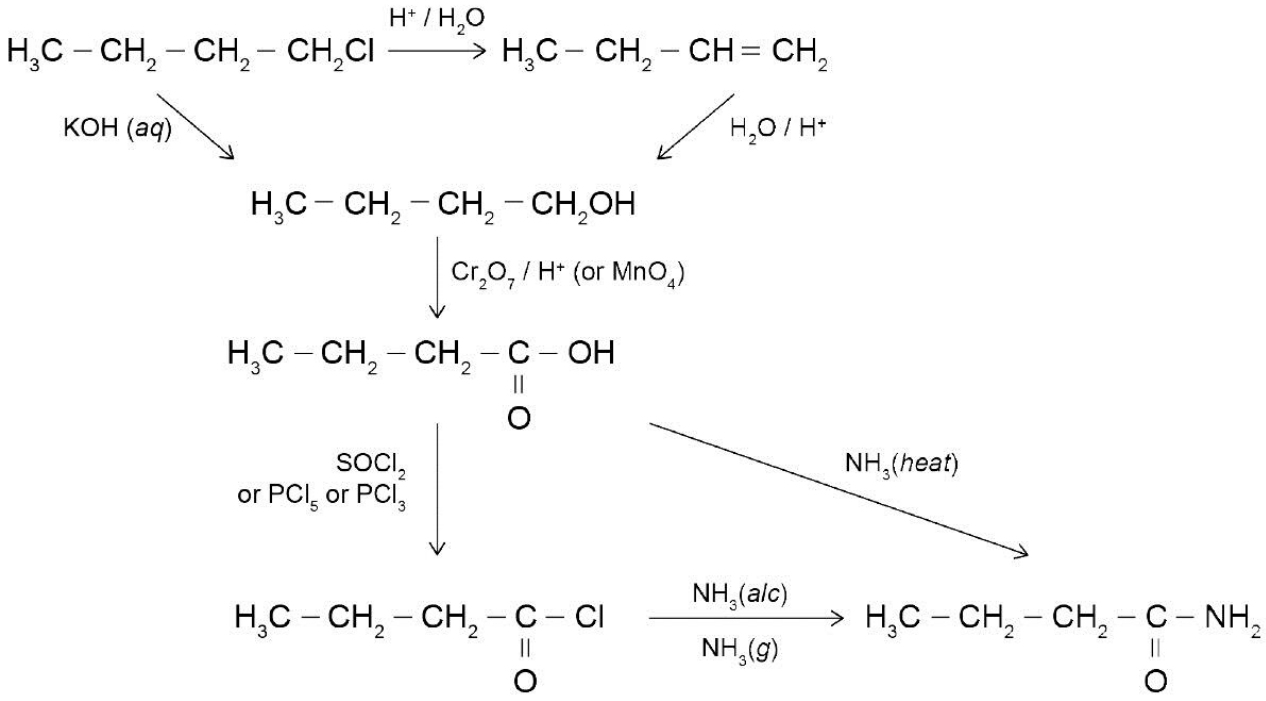
is replaced with Cl.
Hence:



Compound Z
A substitution reaction occurs with CH_3NH_2; the Cl is replaced with CH_3NH_2.
Hence:

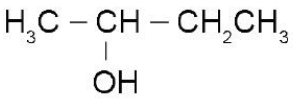


8)

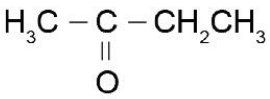


9)

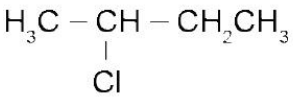
A (butan-2-ol)



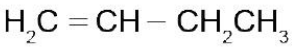
B (butanone)



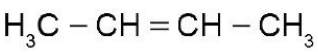
C (2-chlorobutane)



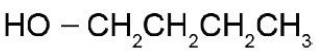
D (but-1-ene)



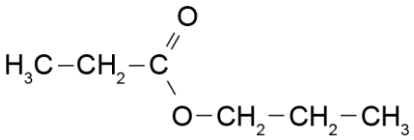
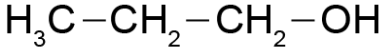
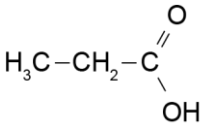
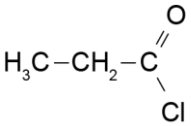
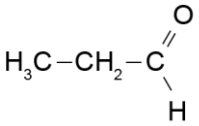
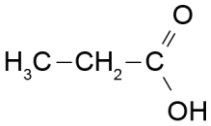
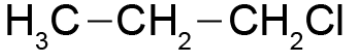
E (but-2-ene)



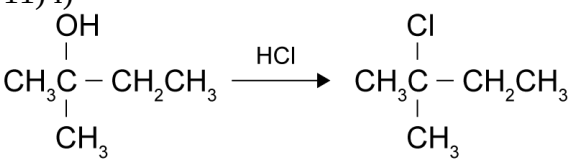
F (butan-1-ol)



10)

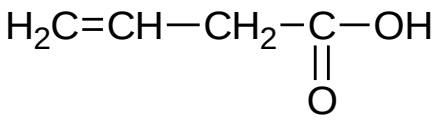
A  propyl propanoate B - sodium propanoate C  propan-1ol (1-propanol) D  OR  propanoic acid propanoyl chloride OR methylpropanoate E  OR  propanal propanoic acid F 	Reagent 1 = NaOH(*aq*) Reagent 2 = NaOH(*aq*), *accept NaOH(alc) if D = acid chloride, Na_2CO_3 (aq).* Reagent 3 = PCl_5 / $SOCl_2$ / PCl_3. Reagent 4 = $Cr_2O_7^{2-}$ / H^+ or MnO_4^- / (H^+) / Fehling / Benedicts/ Tollens *or if D is given as acid chloride, accept PCl_5 / $SOCl_2$ / PCl_3./ methanol or other alcohol + acid to give ester in D.*

11) i)

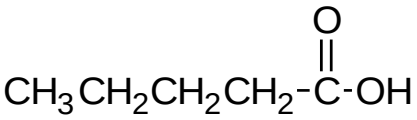


ii) Substitution, the alcohol group is removed and substituted with the chlorine side chain

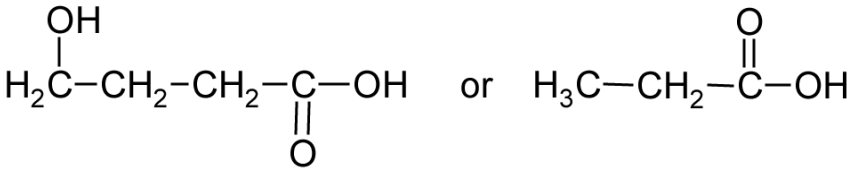
12) **i)** 4-chlorobutanoic acid



ii) pentanal



iii) 4-chlorobutanoic acid or propanoyl chloride

	(or $CH_2OHCH_2CH_2COO^-$ or $CH_3CH_2COO^-$)

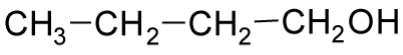
13)

Reagent 1 $H^+ / Cr_2O_7^{2-}$ OR MnO_4^- / H^+ OR MnO_4^-

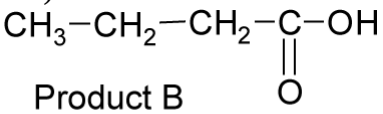
Reagent 2 PCl_3 / PCl_5 / $SOCl_2$ OR HBr OR $SOBr_2$

Reagent 3 PCl_3 / PCl_5 / $SOCl_2$ / conc HCl with $ZnCl_2$ (not just conc HCl)

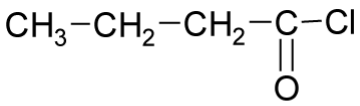
Reagent 4 NH_3 (alcohol not required)



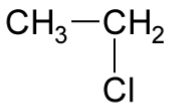
Product A



Product B



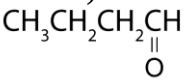
Product C

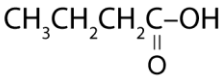


Product D

Alternative answer:

Reagent 1 (as above) and Reagent 2 = Reagent 1 OR Tollens / Benedicts / Fehlings

Product B 

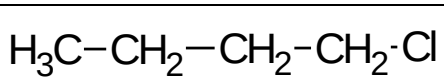
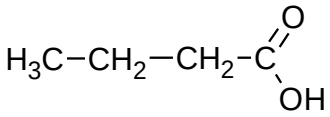
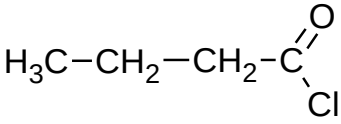
Product C 

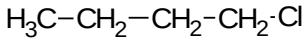
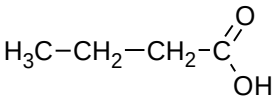
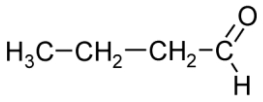
14) Aldehyde (propanal) is obtained by heating a mixture of propan-1-ol with acidified (potassium dichromate) solution or (acidified) permanganate solution. Propanal can be removed from the solution as it forms, using distillation, as the aldehyde has a lower boiling point than propan-1-ol and the carboxylic acid. Carboxylic acid (propanoic acid) is obtained by reacting a mixture of propan-1-ol with acidified potassium dichromate solution (under reflux conditions) until all of the reactant has been converted to propanoic acid.

15)

Reagent	Formula
1	PCl_3, or PCl_5, or $SOCl_2$, or HCl
2	NH_3
3	$Cr_2O_7^{2-}$ / H^+ or MnO_4^-/H^+
4	PCl_3, or PCl_5, or $SOCl_2$
5	CH_3NH_2

16)

Product	Name or formula
1	
2	
3	

Product	Name or formula
1	
2	
3	

17) i) $SOCl_2$ / PCl_3 / PCl_5 NOT HCl

ii) $CH_3CH_2CH(NH_2)CH_3$
Accept recognition that substitution will not occur under these conditions alone.
iii) Reagent 1 $Cr_2O_7^{2-}$ / H^+ or MnO_4^- / H^+
Product CH_3COOH
Reagent 2 NaOH, Na_2CO_3, $NaHCO_3$
iv) Reagent 1 conc H_2SO_4
Product $CH_3CH=CH_2$
Reagent 2 Dilute H_2SO_4 or H^+ / H_2O

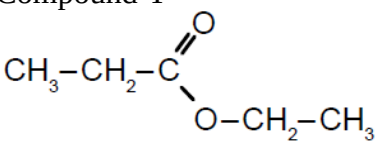
18)

Reaction	Type	Reagent
1	Elimination / Dehydration	conc H_2SO_4
2	Oxidation	$Cr_2O_7^{2-}$ / H^+ or MnO_4^- / H^+
3	Substitution	$SOCl_2$, PCl_3, PCl_5, conc HCl

19) Reagent 1 – **KOH** in **ethanol**/alcohol

Reagent 2 – NaOH(aq) / NaOH/KOH / KOH (aq) /H2O with OH– – *not H_2O*

Reagent 3 – $SOCl_2$ / PCl_3 / PCl_5 – *not HCl)*

Compound X (Minor product): $CH_3CH_2CH_2Br$ or full structure Name of minor product: 1-bromopropane CH_3CH_2COCl is propanoyl chloride	Compound Y  OR CH_3CH_2 $COOCH_2CH_3$ or full structure Name: ethyl propanoate

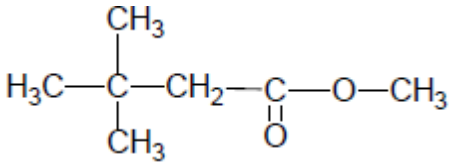
b)

(i) Elimination	The molecule HCl / a Cl atom **and** an H atom removed **and** a double bond is created.
(ii) Substitution	Br^- /Br; is removed and replaced / exchanged /swapped with /changed for / substituted with; an OH^-/OH group.
(iii) Oxidation	Oxygen is added / hydrogen is removed / electrons are lost / the number of bonds to oxygen is increased / the oxidation number of carbon increases / $Cr_2O_7^{2-}$ is an oxidising agent / $Cr_2O_7^{2-}$ is reduced to Cr^{3+} so the alcohol is oxidised.

c) If the major product (2-bromopropane) remains in the flask when reagent 2 (NaOH(*aq*)) is added, a substitution reaction would cause the formation of the 2° alcohol propan-2-ol ($CH_3CH(OH)CH_3$) as well as propan-1-ol) This would in turn be oxidised by the dichromate to the ketone/ propanone/ (CH_3COCH_3). No further reaction with reagent 3 or ethanol will occur, so the final mixture would contain a lot of propanone and a smaller amount of the ester.

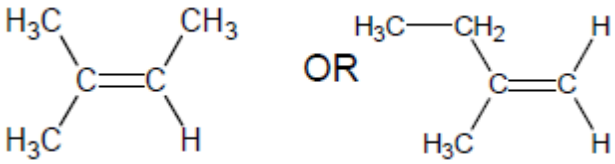
(If all of the alcohol was not completely oxidised to the ketone, an ester with the ester group attached at the 2nd C atom might form with the propanoic acid and 2-chloropropane might result from excess propan-2-ol reacting with reagent 3.)

20)



condensation /esterification/substitution

ii)



elimination